Sacred Heart College
Science Department

Year 12 Science

Resource booklet

Achievement Standard 2.3 (90722)

Evolution of New Zealand Plants and Animals

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Achievement Standard 90772: Evolution of NZ Plants and Animals

This achievement standard involves describing the factors and processes involved in the evolution of New Zealand's plants and animals.

Achievement Criteria

Achievement	**Achievement with Merit**	**Achievement with Excellence**
• Describe the factors and processes involved in the evolution of New Zealand's plants and animals.	• Explain the factors and processes involved in the evolution of New Zealand's plants and animals.	• Discuss the factors and processes involved in the evolution of New Zealand's plants and animals.

Explanatory Notes

1 *New Zealand's plants and animals* means species of plant and animal that are endemic to New Zealand. Examples include takahe, weta, pingao, short-tailed bat, pohutukawa, tuatara, kaka, southern rata.

2 *Factors* involved in the evolution of New Zealand's plants and animals are:
- geological and could include: plate tectonics and the resulting effects such as the break-up of Gondwanaland, changing sea levels in the Tertiary period, volcanism, mountain uplift, and climatic changes
- biological and could include: predation, competition, range of pollinator species.

3 *Processes* involved in the evolution of New Zealand's plants and animals are those that affect the gene pool and could include: mutations, genetic variation, genetic isolation, founder effect, genetic drift, differential selection pressures, bottleneck effect.

4 Terms:
- *Describe* requires the student to give characteristics of, or an account of.
- *Explain* requires the student to provide reasons for how or why.
- *Discuss* requires the student to link scientific ideas to justify, relate, evaluate, compare and contrast, or analyse.

Cover picture: Beech forest, Fiordland National Park. Beech is one of the 3 NZ predominant forest types, the others being podocarp and kauri. Beeches date back to Gondwana days.
Photo: PK

1.1 Natural Selection

Natural selection is the term we use to describe a process in which more "fit" members of a species survive to produce offspring which inherit the characteristics which make them successful. The more fit individuals could also simply be more successful at reproducing to produce offspring which survive. "Fitness" is a term used to describe how well an organism is adapted to the conditions in which it lives.

Because there is variation among the members of a species, some individuals are likely to be more fit for particular conditions than others. Since these individuals reproduce more successfully, and pass on their characteristics, eventually the whole reproductive group will have the characteristics which improve fitness. Therefore these characteristics have been **selected**, and the conditions that produce them are termed **selection pressures**.

In 1859, Charles Darwin published a book, *On the Origin of Species*, in which he proposed that it was through selection acting in a variety of ways that different species arise from a common ancestor. Over time new species evolve to exploit new opportunities in an ecosystem, or species change to adapt to changing conditions. The term that is used for this overall process of change over time is **evolution**. Darwin's theory is now accepted by the vast majority of the scientific community and is supported by a mass of evidence in the form of fossils, genetics, experiments and observations of organisms and biological communities.

Overall, the theories of natural selection and evolution can be used as a **scientific model**, so that with an understanding of the model we can make hypotheses and predictions about :

- the relationships between organisms (contemporary or ancestral)
- the purpose of special features of an organism
- how the special features came about

In this unit we will be applying the evolutionary model to develop an understanding of the special features of endemic plants and animals of New Zealand, and how these came about.

In your Notebooks

Make a heading "Natural selection" Write full sentences which will form a 'note' to answer the following questions

1. What is fitness in biology?
2. Why are some members of a species more 'fit' than others?
3. Why does this lead to changes in a species if the conditions change?
4. Why is the theory of evolution described as a scientific model?
5. What are the different lines of evidence that support the theory of evolution?

1.2 Species

It is difficult to give a definition of species which is both simple and exact. In general terms, biologists use the term species to describe a group of organisms (population) that can actually or potentially interbreed to produce fertile offspring. There are difficulties with this definition, not the least of which is that it only applies to organisms that reproduce sexually. However, as a starting point for the organisms in which we are interested in this unit it is useful.

Binomial names

Biologists us a **binomial** naming system for species, in which the name has two parts. The first part of the name is the **genus**, and closely related species will belong to the same genus. For example, the kea (*Nestor notabilis*) and the kaka (*Nestor meridionalis*) are closely related species that evolved from a common ancestor, and their similar features led to their both being included in the genus *Nestor*. Note that this ancestor was neither a kea or a kaka, but more closely resembles a kaka because its habitat was identical and therefore it had identical adaptations.

The science of classification as family, genus, species and so on is termed *taxonomy*.

Kea (Wikimedia commons)

Binomial species names are "latinized" (i.e. follow Latin grammar), and often relate to a characteristic of the organism or to a person such as the discoverer. For example, a member of the pohutukawa/rata family *Metrosideros* was discovered by the then HOD Science at Sacred Heart College, John Bartlett, and was named after him by the botanist who defined it - its name is *Metrosideros bartlettii*, and its common name is Bartlett's rata.

Writing binomial names:

When referring to several members of the same genus, or to a particular species several times in an essay, it is acceptable practice to shorten the genus name to a letter followed by a period after the first use e.g *M. bartlettii*. The genus always begins with a capital and the species with a lowercase letter. When typing, binomial names should be in italics, and if handwritten should be underlined.

Subspecies

Some species are further broken down into *subspecies***.** For instance the kaka has two recognized subspecies, the North Island and the South Island kaka. There is not such a clear definition of what constitutes a subspecies in biology, but for most NZ species the subspecies have different geographic distribution and some difference in morphology (which means the shape of the visible features), by which they can be distinguished. The scientific names of subspecies are given by adding a third part to the binomial name; for instance, the North Island kaka is *Nestor meridionalis septentrionalis* (the South Island kaka is known as *Nestor meridionalis meridionalis*; the species name is repeated because it

is the “original” version whose characteristics were used to define the species).
In plants the term **variety** is used rather than subspecies; for example, there is a variety of pohutukawa (*Metrosideros excelsa)* with variegated (multicoloured) leaves known as *M. excelsa variegata*. Subspecies and varieties usually arise from some sort of genetic isolation (see section 1.7).
A cross between two species is called a **hybrid.** These are more common in plants than animals. For example, pohutukawa, *M. excelsa* and rata (*M. robusta*) can cross to form a hybrid. Such hybrids are (usually) infertile, which helps maintain genetic isolation.

In your Notebooks

Make a heading “Species” Write full sentences which will form a ‘note’ to answer the following questions

1. What is a species?
2. If two plants can be crossed, but the offspring have infertile seeds, why do we consider these to be different species?
3. What are the rules for writing a species name down?
4. What is a subspecies?

1.3 Adaptations

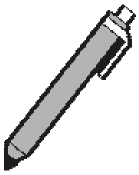
Adaptations are the special features of an organism which help it to survive. Biologists usually classify adaptations into three categories: structural, functional and behavioural.

Structural adaptations are those related to the organisms structure, such as the large feet of the pukeko, which help spread its weight on the soft surfaces common to its swamp habitat.

Functional adaptations are those that relate to the organism's overall physiology, such as the rapid heartbeat of small birds or the sugary sap of a cabbage tree. Sometimes they are a little difficult to tell from structural adaptations.

Behavioural/response adaptations are those that relate to an organisms' behaviour or responses, such as the light-seeking growth of a plant or the fact that kiwi are active at night and seclude themselves in burrows or holes during the day.

In your Notebooks



Make a heading "Adaptations" List the three types of adaptations and give examples

1.4 Genetic variation and inheritance

Organisms in a population do not have identical genes (unless they have been propagated asexually or have been produced from the same zygote). These small differences in **genotype** can result in small differences in the overall physiology of the individual (the **phenotype).** Characteristics which are controlled by many genes, such as the height of a human, are subject to **continuous variation**. In humans, the proportions of several body parts as well as various growth factors control size, and these are all coded for by different genes. An individual **inherits** different combinations of these genes from their parents, and there are many possible combinations resulting in a range of possible outcomes.

Other characteristics, such as purple or white flowers in *Agapanthus* are subject to **discrete variation.** These are controlled by a single gene which the individual either inherits or does not, or else, the gene for the characteristic comes in two forms, one of which will always show up in the phenotype if that gene is inherited. These characteristics are said to be **dominant**; they show up regardless of whether the individual has two

copies or just one of them. You will have learned how to predict the outcome of crosses of this sort in Achievement Standard *Science 1.3.*
There are other characteristics which are the result of the interaction of a small number of genes and have predictable outcomes in crossing, but are more complex than the simple dominant/recessive (Mendelian) crosses to work out.
The overall variation within a population's genes is sometimes referred to as its **genetic diversity,** and the range of various genes available is termed the **gene pool**. Various factors in the environment can, at times, act to reduce the genetic diversity of a population, usually by reducing the gene pool as a result of a large reduction in population. The consequences of this will be discussed later.
In recent years much more attention has been paid to genetic diversity when human intervention is required to prevent the extinction of endangered species and maintain "species authenticity". For example, during conservation work to restore kauri forest to the Coromandel ranges, workers have been careful to use seed taken from the surviving Coromandel trees in order to preserve the genetic identity of this forest as distinct from Northland kauri forest. If Northland seed had been used the genetic diversity of the kauri could potentially have been reduced.

1.5 Mutation

The genetic code in a single cell in an organism can change as a result of a number of factors – e.g. exposure to radiation (natural or manmade), exposure to naturally occurring or manmade chemicals, the action of certain viruses, or "transcription errors" during cell division. In many cases there is little change in the cell, but sometimes the mutant cell can multiply and the resulting mass of cells no longer fulfils its proper function in the body. This is cancer. Mutations of this sort, in **somatic cells** (cells not involved in reproduction) are not passed on.
If the mutation occurs in **germline** cells (i.e. those involved in reproduction), the mutation resulting can be passed on to offspring. Such mutations are random, and therefore most have no effect or are harmful.

Harmful mutations will be rapidly selected against, and disappear from the gene pool. But the laws of probability dictate that a few mutations may result in improved fitness to particular conditions. Such mutations can be passed on, and natural selection in some cases will see the mutation spread into the gene pool.
One of the methods of creating new crop varieties without inserting genes from other organisms involves exposing seeds to levels of radiation sufficient to cause mutations, and raising the resulting plants. Although the vast majority do not have useful mutations, any that do can be interbred to pass on the mutation and create a new variety.
The accumulation of genetic change in a population is known as **genetic drift.** A whole population may be subject to this, and may also undergo significant change as a result if there are selection pressures favoring certain changes (this would normally only be noticeable through fossil evidence, and this is rare). However, the effect is more significant if some factor divides the population so that different parts of it drift in "different directions". This will be examined in more detail in the next section.

In your Notebooks

Make a heading "Genetic variation" Write full sentences which will form a 'note' to answer the following questions

1. What are the two types of variation and why are they different?
2. What is the gene pool?
3. Why do conservationists try to use seeds from the local area when re-introducing plants such as kauri?
4. What are mutations
5. What is genetic drift and how does it arise?

1.6 Niches

An organism's "job" in a community is commonly known as its ecological **niche.** For example, within a forest plant community you will have canopy trees, sub-canopy, undergrowth and so on. However, niches can specialize far more than described by these general terms and organisms often will specialize to avoid excessive competition (this is a selection pressure). So a group of birds might specialize to utilize different types of seeds, or plants might specialize for particular conditions (e.g a stream bank that has more light than the forest floor but insufficient space or soil to allow canopy trees to develop).

There are circumstances in which new opportunities for niches may arise with no opportunity for organisms from elsewhere to migrate in and exploit them – for instance, a new volcanic island may appear a long way from any other landmass. When this happens, organisms which do arrive (e.g, birds blown by a storm) may be able to evolve to fill a niche for which there is no existing exploiter. An example of this is the way that marsupials in Australia adapted to fill the niches which, elsewhere in the world, are normally filled by placental mammals. This adaptation to fill newly available niches is called **adaptive radiation** and will be discussed in more detail later.

1.7 Genetic isolation

In this unit we are primarily interested in the factors which lead to the development of different species or subspecies from a common ancestor rather than change in species over time, although this will also be examined briefly when we look at NZ examples.

The development of separate species requires some sort of isolation which stops the flow of genetic material throughout the whole of the species. Unless such a barrier to gene flow exists, the interbreeding of the members of a species will ensure a degree of genetic uniformity throughout the population effectively keeping them as a species. Something as simple as wide geographical spread can limit this, depending on how reproduction works for that species. For example, if pollination in

a plant is by wind the pollen from widely separate plants can fertilize other plants and keep up gene flow. But if pollination is by insect, it is possible that the pollen may be confined to quite a local area. The rate of gene flow through the population may be sufficiently slow that genetic drift (as described in the section on mutation) may accumulate to the point where there is a difference across the geographical distribution of a population. Initially, this may lead to subspecies where reproduction is still possible if somehow the populations are re-combined. The differences between the sub-populations may be gradual between the extremes. Under the right circumstances, where gene flow is limited for long enough, the genetic drift may continue where interbreeding between subspecies to produce fertile offspring is no longer possible. Thus a new species develops.

A wide geographic spread itself can lead to genetic isolation. For example, if a species has a short breeding season the breeding time may arrive at different times for a northern and southern population, preventing interbreeding.

There are also special circumstances where factors contribute to species developing either more rapidly or in a more pronounced way. Some of these are outlined in the next sections.

<u>In your Notebooks</u>

Make a heading "Genetic differences within a species"
Explain how genetic isolation can occur and how it can lead to new species forming

1.8 Bottleneck effect

This refers to conditions in which the population, and therefore genetic diversity, of a species is greatly reduced. A common cause is habitat reduction (e.g. due to climate change), but disease or the introduction of a new competitor or predator may also cause this. For example, during the Ice Ages (Pleistocene, or glaciations which happened several times in the last two million years) the area of forest in New Zealand was greatly reduced, particularly in the South Island. Forest remained only in low lying

areas (though there were somewhat more of these due to the simultaneous reduction in sea level). Remaining forest cover was no longer continuous, as forested areas were divided by highlands of tussock and alpine vegetation. As a result, many populations of native plants and animals were greatly reduced and isolated from each other, and new species developed.

1.9 Founder effect

This is the term used to describe the situation where a population is founded by a very small number of ancestors, such as a single breeding pair, or a single seed of a plant capable of self-fertilization. When this occurs, any genetic traits particular to the ancestor/s are likely to be preserved in the entire descendent population. Recessive traits will be common because of the large amount of homozygosity (i.e. genetic traits in which the same trait is inherited from both parents and is present in both gametes).

An example is the Chatham Island black robin. These were probably established in the last few thousand years by just a few birds blown out to sea and lucky enough to find land rather than perish. The Chathams are a very small target in a large ocean, so the chances of this occurring are small and so it occurs infrequently. The total population on the islands is also small. If any of the Chatham subspecies are blown back to the mainland (which also won't happen frequently because the island population is small compared to the mainland one) they will find themselves in a much larger population of robins, so the genes they bring with them (which result in the black colour of the island robin, as opposed to the brown of the mainland one) will be greatly "diluted" and will have little effect on the whole population. For this reason, the Chatham Island robin has formed a distinct subspecies with a black coloration.

In your Notebooks

Make a heading "Other causes of speciation" Explain the terms 'Bottleneck effect' and 'Founder effect' and discuss how they effect evolution.

Section 2: Origins of New Zealand plants and animals

2.1 Introduction

NZ plants and animals (or flora and fauna) can be divided into four broad groups.

1. The flora and fauna that were carried with NZ when it split from Gondwanaland some 80 million years ago. By about 75 million years the proto-Tasman sea would have been sufficiently wide to prevent further arrivals save for basically the same sorts of things which can still come to NZ by natural mechanisms. The species that fall into this category are sometimes referred to as the *Gondwana remnant* flora and fauna. Some scientists think that all of the present-day NZ landmass was submerged about 35 million years ago (during the Oligocene), and all that NZ flora and fauna has therefore arrived from elsewhere. But, regardless of this argument, there are (particularly for flora) a good range of species with clear links to Gondwana forms known from fossil evidence, and which are only found in NZ.
2. Animals and that have arrived here since the split from Gondwanaland. These need to be able to survive a journey across several thousand kilometres of ocean. The fauna is mostly aerial – birds, bats and flying insects. But some non-flying insects and reptiles seem to have arrived on driftwood masses, probably washed out to sea during floods in Australia or elsewhere in the South Pacific. More plants have arrived since the Gondwana split, arriving as wind-blown seeds or seeds stuck to, or in the droppings of, migratory birds. Many of these species are subject to a strong founder effect.
3. Migratory birds and marine/amphibious species. Animals that are not exclusive to NZ fall outside the scope of our study, but some of these animals have “settled” in NZ and evolved into forms that are now endemic e.g. the Hector’s Dolphin.
4. Organisms brought here by human agency e.g. the kiore, kumara and opossums. We are not examining the evolution of these species,

although in the case studies we will look at some of the ecosystem change wrought by them.

2.2 The Gondwana remnants

New Zealand began to split from the "eastern" coast of Gondwanaland about 80 million years ago (see the Geology section). The split would have begun as a rift valley, similar to that which runs along the eastern part of the African continent today. This split would have widened into a narrow sea, similar to the Red Sea today, and then to a proper but small ocean. You will learn more details about this in the course for Achievement Standard 2.5 on the geological history of New Zealand. The significance for this unit is that, over time, it would have become progressively more difficult for organisms to travel between NZ and the Gondwana mainland. The time of the proto-New Zealand continent's split from Gondwanaland is the time we call the late Cretaceous – in fact, about the same time as the famous dinosaur, *Tyrannosaurus rex* appeared. However, this dinosaur never made it to NZ. The proto-NZ continent had been uplifted from the sea and formed mountainous terrain about 50 million years earlier, and at the time of the split had been significantly worn down in a process known as *peneplenation* (this will also be covered in more detail in the geology unit). However, much of present day NZ was still above water at the time and the fossil record of it is therefore poor.

There are dinosaur fossils from this time known, and a few coal beds which contain plant fossils giving us important clues about the relationship between present day NZ plants and those of this era. As well as this, there are plant fossils elsewhere in the world showing us very clearly that much of the flora of the three dominant forest types (kauri, podocarp and beech) of NZ is little changed from that of the early to mid-Cretaceous. NZ is truly, in this sense, "the land that time forgot". This is why quite a few episodes of "Walking with dinosaurs" were shot here – there are few other places in the world which so closely resemble the way things were in the age of the dinosaurs.

The event(s) which caused the extinction of the dinosaurs occurred 5

million years before the Tasman Sea reached its present width; the "K-T boundary" event, as it is known, occurred 65 million years ago and the Tasman stopped widening some 60 million years ago. Though whatever caused the boundary events happened far away from NZ, the geological record here shows an unusual layer of clay at exactly this time. Above (i.e. after) this clay layer, there are some profound changes in the fossil record which suggests that, even here, this event caused widespread extinction. There is no evidence that any NZ dinosaurs survived this extinction event.

After New Zealand reached its present position it continued to erode away. This caused the land to lose relief (hills and valleys), and the resulting flat landscape became extensively swampy by about 45 million years ago. Gondwana remnant trees similar to the modern kahikatea dominated; this swampland eventually formed the coal measures of the Waikato, Southland and elsewhere. The subdued landscape eventually mostly submerged below the sea, leaving only a few small islands. These islands were not able to contribute much sediment, so the only rock-forming material from this era was shellbeds, forming the extensive Oligocene limestones in which most NZ caves are found.

The Oligocene submergence probably caused a fairly strong bottleneck effect, leaving only a few survivors. Among the Gondwana remnants which survived this are the tuatara and the weta; these seem to have changed little from the Cretaceous, probably because no strong selection pressures acted on them to do so.

Another Gondwana remnant which also survived the Oligocene bottleneck was the moa. Adaptive radiation seems to have caused this class of ratites to speciate to fill niches that in most places are filled by mammals.

Some scientists argue that none of present day NZ was land during the Oligocene. The arguments are complex, based on geology and biology. Given some of the constraints (moa completely lack even remnant wings, so they could not have flown here and they are probably too large to have rafted here on driftwood masses), it seems likely that even if this were the case there must have been parts of the NZ continent above water at this time, possibly parts which are now submerged (about ¾ of continental NZ is presently underwater). This Oligocene landscape must have been

connected for a time to the parts of NZ which were uplifted and became land 22 million years ago in the Miocene.
Some of the NZ Gondwana remnant flora and fauna is closely related to species found in places such as Norfolk Island, New Caledonia and Papua New Guinea. These places were part of the same eastern Gondwana bloc that NZ originated from, supporting the idea that they originated from similar populations. For example, the kauri has close relatives on Norfolk Island and in New Caledonia.
Some of the main categories of Gondwana remnant biota:

Gondwana species
Flora:
· Conifer (kauri), podocarp and beech (*Nothofagus)* trees
· Ferns, particularly tree ferns, · Possibly the nikau palm

Fauna:
· Moa, Tuatara· Weta· Carnivorous land snails· Giant worms Some frogs

3.3 Later arrivals
Other species arrived in New Zealand after the separation from Gondwanaland. For example, the kiwi has small remnant wings (only the moa, among ratites, is completely wingless) suggesting its ancestors possibly flew here. However, since its arrival it has been subject to selection pressures and has become highly specialized and flightless.
Other than by flight, some animals may have arrived on floating masses of driftwood. It is quite a well known phenomenon in large, flood-prone rivers for tangled masses of vegetation to be ripped up by floodwaters and carried out to sea. Sometimes these masses have “hitchhikers”. Mostly, they die before reaching another landmass, or they do not have a breeding partner.
The thing to keep in mind when thinking about this sort of occurrence is the sheer scope of geological time. Suppose a drifting mass containing a species capable of establishing in New Zealand arrives only once every ten thousand years. This still means it will happen about *one hundred times* in

a million years. NZ separated from Gondwanaland 80 million years ago, so many such events could have occurred. In practice, events like this are highly random, but even very infrequent or unlikely occurrences can have a significant impact over millions of years.

Plants and animals which arrived here without human assistance have became adapted to the peculiar conditions found here, such as the absence of predatory mammals or of large mammalian herbivores. This has resulted in a number of highly unusual species, many of which have fared very poorly since the rampant introduction of new species by humans. Examples will be considered in the case study section.

Some arrivals have "arrived" more than once; for example, the takehe has descended from a common ancestor with the pukeko but arrived several million years ago and evolved into the flightless form. NZ pukeko are very similar to the Purple Swamp Hen found in Australia and elsewhere; they arrived in NZ of their own accord within the last million years and have evolved little.

Post-Gondwana arrivals

Flora:

· Most dicotyledons, including flowering shrubs and trees e.g. *Hebe, Metrosideros* (rata family)*, Coprosma, Leptospermum* (ti tree)*, Pittosporum* etc. NZ daisies, alpine-adapted groundcover

oMangroves (arrived 14,000 years ago)

·Monocotyledons e.g *Phormium* (flax) and *Cordelyne* (cabbage tree), grasses (including raupo and tussocks), orchids, rengarenga

Fauna

· Flying birds (tui, waxeye, morepork etc.); many of these have diverged into completely separate species from their ancestors and some have become nearly flightless (e.g. weka)

Flightless birds which have descended from a flying ancestor e.g. kaka, takehe, kakapo, possibly the kiwi (or possibly not)

· Some non-migratory shorebirds descended from migratory ancestors

· Most fresh-water and estuarine fish· Hector’s and Dusky dolphins
· Lizards (skink and gecko)

Factors and processes in NZ evolution

Factors

- Geological
    - Sea level change
        - Rise in sea level can isolate areas by creating water where there was once dry land e.g. Cook Strait
        - Reduction in land area may cause bottleneck
        - Fall in sea level may create land bridge, allow incursion of new species and change ecological balance
    - Plate tectonics
        - Opening up of Tasman Sea – isolated NZ from Gondwana at time before mammals dominated, before flowering plants & grasses; hence NZ dominated by birds and conifers
        -
- Biological
    - Predation
        - NZ species – few predators prior to humans (moa and Haast Eagle
    - Disease
    - Competition
    - Pollinating species

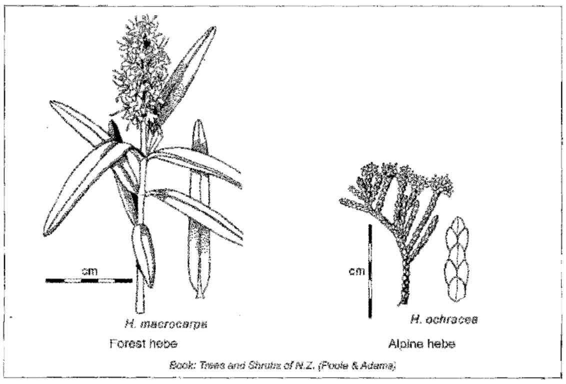
Review questions

Question One: Hebes

Hebes are endemic New Zealand plants with about 100 species. They occupy areas from forests to the high alpine environments.

The two hebes shown in the diagram above evolved from a common ancestral population of the forest type and have evolved distinct characteristics.

1. Describe ONE key difference between forest and alpine hebes.



The ice ages created small populations, or bottlenecks, which contributed to the evolution within the hebe.

2. Explain how the ice ages created bottlenecks of hebe populations.

The difference in the present day species is in part caused by differential selection pressures.

3. Explain what differential selection pressures are.

4. Discuss how the differences between H. macrocarpa and H. ochracea may have arisen from such pressures.

Question Two: The Evolution New Zealand parrots

The present day kaka and kea have evolved from a single forest-dwelling parrot species that became separated geographically about 3 million years ago. The parrot that evolved in the lowlands of New Zealand became the kaka, which specialised in exploiting the area's more predictable food resources.

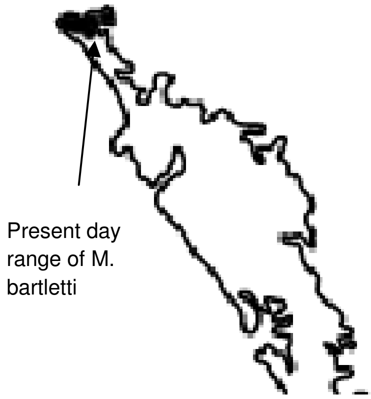
The kea, ~meanwhile, evolved in the colder alpine environment where food supplies were less predictable.

1. Give TWO geological factors that changed the environment and contributed to the evolution of the kea in the last 3 million years. (U2.1 fauna)

2. Explain how ONE of the geological features in (a) contributed to the evolution of the kea.

Question Three: Metrosideros

Both pohutukawa and rata belong to the genus Metrosideros. There are two species of pohutukawa (Mainland, M. excelsa and Kermadec, M. kermadecensis), and six species of rata vine, a shrub and three tree rata.



Modern pohutukawa and rata species have all evolved from an ancestral species of tree that grew in New Zealand over 65 million years ago.

1. Explain the significance of the geological factor that occurred around that time.

One of the rata species, Metrosideros bartletti (named after John Bartlett, formerly HOD Science at Sacred Heart College), is found only around North Cape. This area was once an island and is now connected to the mainland by a tombolo of sand deposited during ice-age sea-level changes

2. Discuss the factors likely to have led to the evolution of this separate rata species

Question Four: The Black Robin

The Chatham Island Robin (also called the black robin) was first discovered in the 1870's. They are distinctly different from the robins found on the mainland because of their feather colour. The different feather colour from the mainland species may be a result of the founder effect..

1. What is the founder effect?

The Chatham Islands have probably never been connected to the mainland.

2. Explain why, in view of this, it is a reasonable hypothesis that the subspeciation of the Chatham Island black robin is an example of the founder effect.

Discuss why genetic drift is also a probable occurrence in this instance.